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INHIBITING EFFECT OF SOD ON THE GROWTH OF HYBRID POPLAR

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ABSTRACT

Dormant cuttings of hybrid poplar were planted in sod, circular scalps 6, 12, and 24 inches in diameter, and plowed ground. Survival for all methods of site preparation was sufficiently high to be rated successful in ordinary practice, but the average height growth on sod was 10 inches as compared to 45 inches on plowed ground. The poor growth vigor on sod and on the smaller scalps indicates that hybrid poplar can not be successfully established on grass land without adequate site preparation.

In the light of past experience, it is extremely doubtful whether better results can be expected on grass land from the use of 1-year-old rooted trees instead of dormant cuttings.

RECOMMENDATIONS

The following recommendations are based on the experimental work reported herein, and to some extent on the writer's previous experience with hybrid poplar.

1. Poplar cuttings should not be planted directly in sod.

2. On heavy sod, site preparation should be equivalent to 24-inch scalps, and spacing should be close enough to result in a closed canopy within two or three years. A smaller sod-free area may be sufficient on light sod.

3. It is impossible to give specific recommendations on spacing because the growth rate of hybrid poplar will depend upon local site and climatic conditions. On heavily sodded sites in western Maine cuttings spaced 4 x 4 feet in 24-inch scalps or 18-inch furrows will produce a closed canopy within two or three years, and will gradually shade out the remaining sod. Where a longer growing season or lighter sod will result in increased growth, wider spacing will be practicable.

4. Planting in furrows made by plowing out a shallow strip of sod on each side of the center line (so-called "dead" furrows) is recommended on plowable areas as a cheaper method of site preparation than 24-inch scalps, particularly with relatively close planting. Planting in furrows has been used by one cooperator in Michigan, apparently with excellent results. On the basis of the experimental results on scalped areas, it is recommended that on heavy sod furrows should not be less than 18 inches in width.

5. At least one cultivation during the first growing season is recommended if the grass encroaches upon the scalps or furrows, particularly in sod of the quack grass type.

INTRODUCTION

Widespread planting activity, resulting from increased interest in and recognition of the necessity for conservation, has indicated a lack of information on planting methods required for the successful establishment of hardwood species. A high percentage of hardwood plantings have failed because they have been made on grass land without adequate site preparation. The fact that, in general, conifers are able to survive in sod has led to the erroneous conclusion that hardwood species might be successfully established on grass land with the same planting methods.

The difficulty of establishing hardwoods on grass land has brought the writer many requests for hybrid poplar stock from individuals and planting agencies who were looking for a tree which could be established where other species had failed. Unfortunately, poplar species and hybrids can seldom be used as a last resort under conditions which have led to failure with other hardwoods.

Planting experiments started with hybrid poplars in 1925 by the Oxford Paper Company indicated that successful plantations could not be established on grass land without adequate site preparation. In these early experiments in western Maine both dormant cuttings and 1-year-old rooted trees were used. Although the average survival on grass land at the end of the first year was over 90 percent, ten years after planting survival was less than 1 percent, and the average height of the trees which remained was less than 8 feet; average height on cut-over hardwood land was 30 to 40 feet. Since the planting program of the Oxford Paper Company was directed toward the establishment of hybrid poplars on cut-over forest land, experimental planting on grass land was discontinued after the second year.

The Northeastern Forest Experiment Station has been continuing research with the Oxford hybrid poplars since 1936, and cooperative nursery tests of the new hybrids throughout the United States already indicate in a preliminary way the hybrid clones best adapted to climatic conditions in various localities. The next step is to test in forest plantations the hybrids which have been selected in each cooperating nursery. For this reason and to answer more specifically hundreds of requests for information on the establishment of poplar plantations, most of which indicate that planting on grass land is contemplated, a planting experiment was initiated on sod land at Frye, Maine, in the spring of 1939.

MATERIALS AND METHODS

The area selected for this experiment was on level farm land which had not been plowed for a period of fifteen years and was covered by a dense sod of quack grass. Fig. 1, Plate I, illustrates the uniformity of the experimental area and shows one of the experimental blocks in the background.

Twelve-inch dormant cuttings of two hybrid clones from crosses between Populus maximowiczii x P. trichocarpa and P. maximowiczii x P. berolinensis respectively, were graded to a middle diameter[1] of 0.3 to 0.4 inches. It should be noted that this stock was probably the most uniform available for any planting experiment since the use of clones[2] eliminated genetical variation among the individual cuttings of each hybrid; every individual of a clone, with the rare exception of sports, is genetically identical with every other member of that particular clone.

The experiment was laid out in two randomized blocks of ten plots 21 feet wide x 45 feet long. One method of site preparation was applied on each plot, which was then planted with 105 cuttings of a single clone spaced 3 x 3 feet. The five site preparations were as follows:

1. None--cuttings were planted directly in the sod
2. Six-inch circular scalps[3]
3. Twelve-inch circular scalps
4. Twenty-four-inch circular scalps
5. Plowing

The scalps were made to exact size by cutting the sod around circular disks of heavy cardboard, and after the circular sod had been removed the shallow holes were filled with soil from the edges of the experimental blocks. The plowed land was worked with both disk and spring-toothed harrow.

The cuttings were planted in the center of each scalp at a uniform depth of 8 inches after site preparation on all plots had been completed. It was thus possible for two experienced men to plant all the cuttings in one block on the same day; block I was planted on June 13 and block II on June 14. The plots were carefully hand-hoed and weeded at frequent intervals during the entire growing season to keep all grass out of the plowed and scalped areas.

1/ Diameter at the middle of the long axis.
2/ The term clone is used to designate a group of plants which has originated by vegetative propagation from one individual [illegible]
3/ A scalp is an area from which the sod has been removed.

Data on survival, total growth of all shoots, and length of the longest shoots were recorded for each individual tree on July 10-12, August 10-12, and November 14-16, 1939. In the opinion of the writer the total length of all shoots on a 1-year-old tree is a better measure of growth vigor than the length of the longest shoot. This is particularly true in a comparison of 1-year-old poplar clones which vary in inherent branchiness. A rooted poplar cutting with four shoots may represent greater growth vigor than one with a single shoot, although the height of the single-stemmed plant may be appreciably more than that of the four-branched type. For this reason the effect of site preparation was compared on the basis of the total growth of all shoots as well as on the growth of the longest shoots. Growth was completed about the third week in September; the last measurements therefore represent survival and growth at the end of the first growing season.

At the end of the growing season five trees were dug from each plot with sufficient care to permit observations on root number and diameter. Since it was not possible to dig complete root systems (because of the fineness of the poplar roots and the density of the sod), root diameter, measured just beyond the swelling at the juncture of root and stem, was used as a criterion of root growth.

All data have been subjected to statistical analysis which has been omitted from this paper but will be included in a later publication.

EXPERIMENTAL RESULTS

The practical results of this experiment are apparent from the photographs in Plate I and the diagrammatic presentation in Plate II.

Effect of Site Preparation

Survival

Survival on July 11, August 11, and at the end of the first growing season is given in Table I.

Table I

Survival--in Percent

Date	Sod	6-inch scalps	12-inch scalps	24-inch scalps	Plowed
July 11	100.0	96.7	98.6	98.8	99.2
Aug. 11	95.4	83.1	94.0	96.4*	95.7
End of first growing season	92.8	79.3	94.5	96.9*	95.7

*A cutting reported dead in August sprouted from below the ground line and was therefore recorded as living at the end of the growing season.

Growth of All Shoots

The average growth of all shoots is summarized in the following table.

Table II

Average Growth of All Shoots
(In inches)

Date	Sod	6-inch scalps	12-inch scalps	24-inch scalps	Plowed	[illegible] 1/
July 11	5.43	4.68	6.03	6.14	7.03	[illegible]
Aug. 11	12.42	11.59	16.64	27.87	39.62	[illegible]
End of first growing season	12.83	12.65	22.32	45.23	98.42	[illegible]

The greater average growth on the 24-inch scalps as compared to sod, 6- and 12-inch scalps respectively, and the markedly increased growth on the plowed plots over all other site preparations, were highly significant.

Growth of Longest Shoots

The length of the longest shoot on a 1-year-old rooted cutting is practically the total height of the tree. The average growth of the longest shoots for each site preparation is shown in Table III.

Table III

Average Growth of Longest Shoots
(In inches)

Date	Sod	6-inch scalps	12-inch scalps	24-inch scalps	Plowed	[illegible] 1/
July 11	3.74	3.10	4.02	3.76	3.86	[illegible]
Aug. 11	8.71	8.18	10.26	14.51	16.29	[illegible]
End of first growing season	9.52	9.30	15.94	23.29	44.96	[illegible]

The differences in growth on 24-inch scalps as compared to sod, 6- and 12-inch scalps respectively, and the differences between plowed and all other treatments, were all highly significant.

1/Standard Deviation

Number and Diameter Growth of Roots

Table IV

Average Number of Roots Per Tree and Average Diameter of Roots in Mm.

	Sod	6-inch scalps	12-inch scalps	24-inch scalps	Plowed	S.D.
Av. No.	23.15	23.15	25.85	27.10	23.45	± 1.704
Av. Diam. (in mm.)	0.88	0.97	0.98	1.33	4.1	± 0.187

The statistical analysis of the data indicated no significant difference between the number of roots produced in response to the different methods of site preparation. There was likewise no significant difference between average diameter of the roots on sod, 6-, 12-, and 24-inch scalps, but the large difference in average root diameter between plowed and all other site preparations was highly significant.

Differences between Hybrid Clones

There were no statistically significant differences between the two clones in survival or in growth of all shoots at any time throughout the growing season. On July 11 there was a significant difference between clones in the average growth of the longest shoots, but this difference had disappeared by August 11 and did not reappear in the November measurements.

There was a highly significant difference between the average number of roots; one clone produced an average of 19.9 roots per cutting, whereas the other clone produced 29.2 per cutting (S.D. ±1.078). The average root diameter of the two clones was 1.74 mm. and 1.54 respectively (S.D. = ±0.374); the difference was not statistically significant.

DISCUSSION OF RESULTS

Inhibiting Effect of Sod

The lack of statistically significant differences in the number of roots per cutting with different methods of site preparation indicates an inhibiting effect of sod on growth and not on initial root formation. The inhibiting effect on growth is apparent from the following table which lists the percentage of the first year's growth completed by July 11 and August 11 respectively. The percentages in Table V were computed from the data in Tables II and III.

Table V

Percent of First Year's Growth

Site Preparation	Average Growth of All Shoots			Average Growth of Longest Shoots		
	July 11	Aug. 11	End of Growing Season	July 11	Aug. 11	End of Growing Season
Sod	42.5	96.8	100	39.5	91.6	100
6" scalps	37.0	94.0	100	38.3	88.0	100
12" "	27.0	74.6	100	28.8	73.6	100
24" "	14.2	64.5	100	16.1	62.3	100
Plowed	7.1	40.3	100	8.6	40.6	100

The early completion of growth in sod as compared to plowed land and the gradation of values for intermediate treatments indicate that the earliness, and thus the extent, of the inhibiting effect of sod depends upon the area of sod-free soil available.1/ The data also indicate that on plowed land growth continues to the end of the normal growing season, whereas on sod and scalped areas growth is strongly retarded and even prematurely terminated by the surrounding sod.

1/ The areas of 6-, 12-, and 24-inch circles are approximately 28, 113, and 452 square inches respectively. The area of sod-free soil in a 12-inch circular scalp is thus four times as large, and in a 24-inch scalp 16 times as large, as in a 6-inch scalp.

The absence of any statistically significant difference in growth on sod as compared to the other methods of site preparation on July 11 can be explained on the basis of uniformity of growth vigor of the dormant cuttings. Since shoot growth on cuttings planted in June usually starts before roots appear, the early shoot-growth must be dependent upon the stored food in the cutting itself. Up to July 11 the growth of the cuttings had apparently not yet become primarily dependent upon the relatively few short roots which had developed.

The results show clearly that dormant cuttings of hybrid poplar can not be successfully established on heavy sod without adequate site preparation, and that growth on 6-inch scalps was no better than on sod. The fact that on 12-inch scalps the growth in mid-August represents 75 percent of the total annual growth indicates sufficient inhibition to make eventual establishment problematical. Twenty-four-inch scalps were sufficient for rather vigorous growth during the first year, although 64 percent of the total growth had been completed by August 11. The highly significant difference between top growth, and particularly the relatively large difference between average diameter of roots on 24-inch scalps and on plowed ground, demonstrates the drastic inhibiting effect of sod and the need for ample growing space.

Plowed ground gave the best results, but at least three factors are involved in this method of site preparation: 1. elimination of the inhibiting effect of sod; 2. increased soil fertility (decaying sod); and 3. a change in the physical condition of the soil as a result of plowing. From the practical standpoint the individual effect of each of these factors is unimportant because in practice they could not be separated. (In an experiment planned for 1940 the effect of these factors will be studied separately by "skinning" the sod from the experimental plots with, and without, loosening of the underlying soil.)

The present experiment does not explain the nature of the inhibiting effect of sod roots on the growth of the trees. Although the most obvious explanation is competition for moisture and nutrients, it may also be due, at least in part, to mechanical interference to the poplar roots or to a toxic effect of substances produced by the grass roots. During the process of digging trees for root measurements it was observed that the poplar roots, growing more or less horizontally through a scalped area, dipped sharply downward as they reached the surrounding zone of grass roots. Relatively few roots penetrated far into the sod. On the basis of earlier irrigation and fertilizer experiments on sod land planted to hybrid poplar, and on the relatively small diameter growth and the direction of growth of the poplar roots in scalps, the writer is inclined to credit the possibility that mechanical interference, or more likely toxic effect of the growing sod, may be contributing factors.

Differences between Clones

The significant difference between clones in total growth of the longest shoots in July, and the lack of any significant difference later in the growing season, was probably due to a frequently observed difference in inherent earliness of budding. Although some clones start their shoot growth after planting sooner than others, root initiation in the early budding types may be delayed, a condition which results in early growth differences which may become equalized over longer periods.

The difference between clones in the average number of roots per cutting is also an inherent characteristic. The inherent rooting capacity of both clones, however, is sufficient for practically 100 percent survival with proper selection of cutting stock. The lack of any significant difference between these two clones in top growth and in average diameter of roots leads to the conclusion that the difference in average number of roots is of little, if any, practical importance.

Use of 1-year-old Rooted Trees

Although this experiment involved the use of dormant cuttings only, the writer's experience with hybrid poplar during the past fifteen years indicated that 1-year-old rooted trees will not give appreciably better results on grass land. Three- and four-year-old trees have been successfully used in Europe for establishment of hybrid poplar plantations on sod land; the planting of such large trees obviously results in a wide area of sod-free soil around the tree. In most cases the planting costs for stock of this size would be prohibitive.

The earlier research of the Oxford Paper Company in western Maine showed that with a reasonable soil moisture content during June and early July cuttings could be readily rooted on cut-over hardwood land, and that rooted trees were necessary only on sites which became abnormally dry before the middle of July. Since sod apparently does not reduce the number of roots produced by a cutting but does inhibit the growth of roots and shoots, it is extremely doubtful whether on a normally moist site 1-year-old rooted trees would become better established in sod than dormant cuttings.

PHOTOGRAPHS

Photographs 1 to 6 were taken on September 30, 1939, at the end of the first growing season. The measuring rod is 4 feet high.

Descriptions of individual photographs face Plate I, p. 11.

EXPLANATION OF PHOTOGRAPHS

PLATE I

1. PLANTING SITE.--One of the experimental blocks can be seen in the background. The photograph was taken from the boundary of the second block.

2. SOD PLANTING.--One of the tallest trees can be seen in the center foreground. Average height growth on sod was 9.5 inches.

3. SIX-INCH SCALPS.--Growth in 6-inch scalps was no better than in sod. Average height growth was 9.3 inches.

4. TWELVE-INCH SCALPS.--Cuttings planted in 12-inch scalps give the impression of successful establishment, but the average height growth, 13.9 inches, indicates sufficient growth inhibition to make eventual establishment problematical.

5. TWENTY-FOUR-INCH SCALPS.--Circular scalps of this size, or an equivalent area of sod-free soil, are probably a minimum requirement for the successful establishment of poplar hybrids on dense sod. But even on 24-inch scalps spaced 3 x 3 feet the average height, 23.3 inches, was much less than the average growth on plowed land.

6. PLOWED GROUND.--The average height growth of hybrid poplar on plowed grass land was 44.9 inches, almost double the growth on 24-inch scalps.

Photographs 7 and 8 show root growth with different methods of site preparation. The trees in each photograph are members of a single clone, and from left to right were dug from plowed ground, 24-, 12-, 6-inch scalps, and sod, respectively. The rule at the right is 12 inches long. Complete root systems could not be obtained; on plowed ground the longest roots were over 8 feet long.

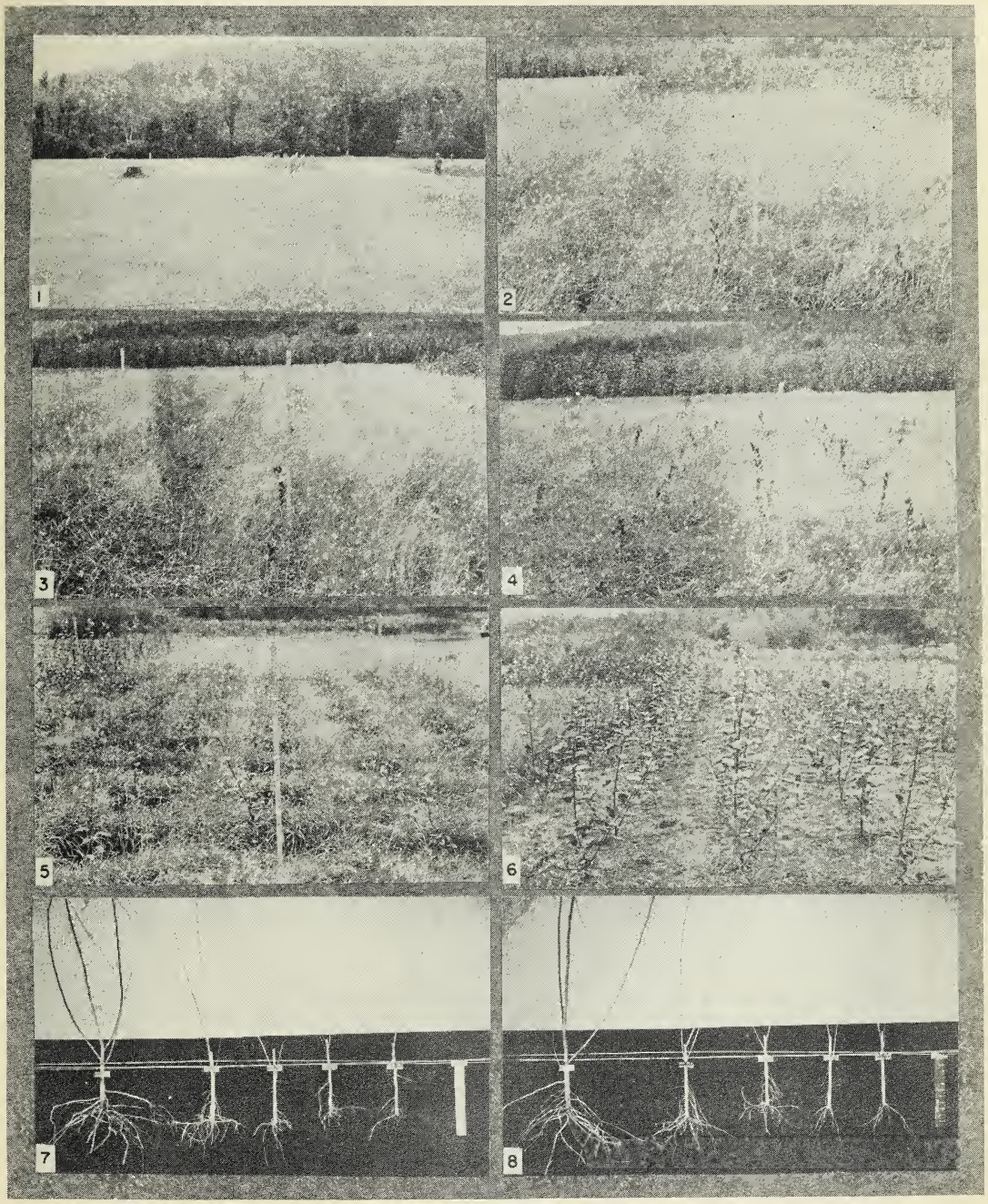
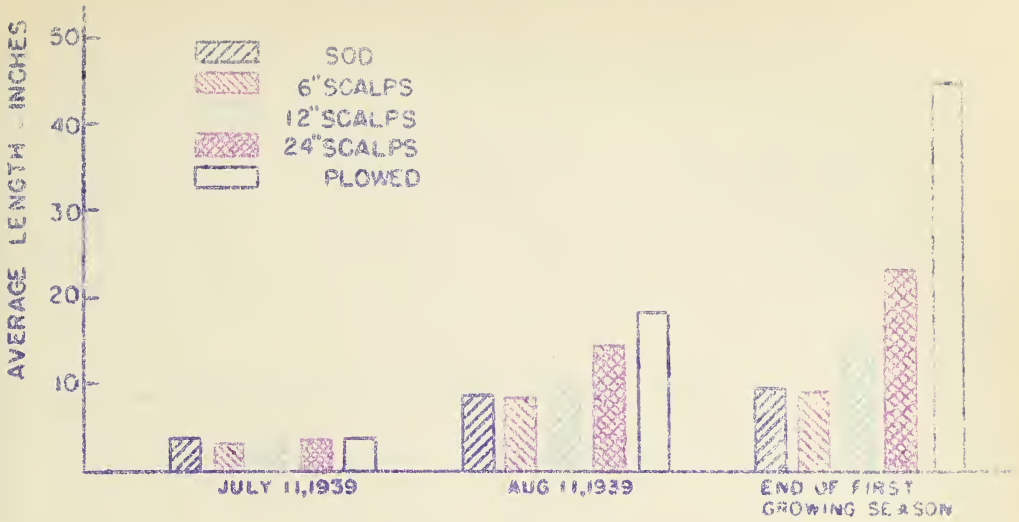
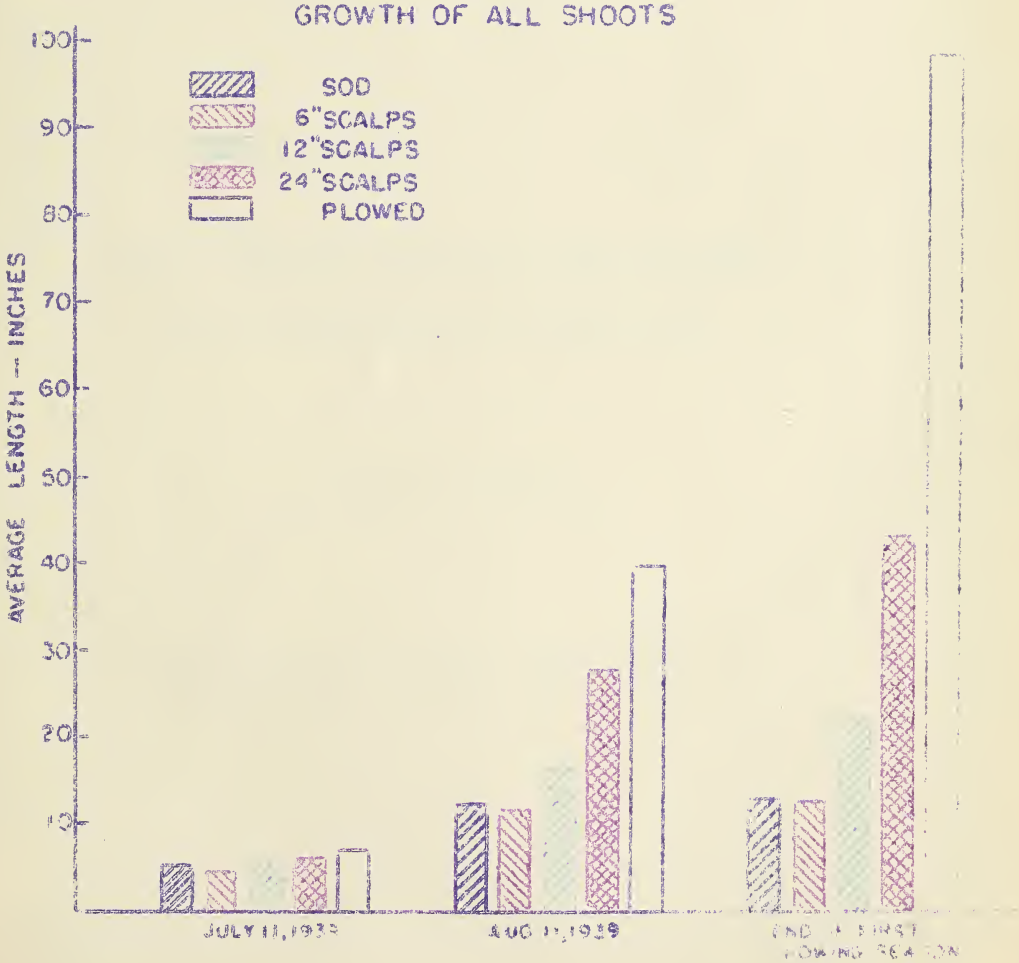


PLATE I

GROWTH OF LONGEST SHOOTS



GROWTH OF ALL SHOOTS



GROWTH OF HYBRID POPLAR ON GRASS LAND

PLATE II